Change in predominant frequency of PC girders during bridge construction

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1. Introduction

Predominant frequency and damping ratio are the bases for studying the dynamic properties of bridge structure. Bridges are subjected to dynamic loads in the form of vehicular traffic, which causes bridges to vibrate. When a vehicle passes over a bridge, certain impact or dynamic amplification effect will be induced, which needs to be taken account in the design of bridge. So, for dynamic loading, dynamic analysis is necessary. The study of dynamic properties of PC girders should be done from initial phase of bridge construction to its design life to know the actual performance of the bridge.

The primary objective of this paper is to clarify the change in predominant frequency of PC girders at different stages of construction of bridge using microtremor. It includes the comparison of Fourier spectra at various phases of bridge construction. Microtremor observation is very effective tool to estimate the dynamic responses of bridge. Vibration frequencies can be easily obtained through microtremor measurement in cost effective way. The study area is Yoshida Bridge which is being constructed. Yoshida Bridge is located at Oaza Nishiyama Kikuma town of Imabari city. The overall dimension of bridge is 17.2m length, 15.719m wide at south end and 11.983m wide at north end. It consists of 14 numbers of PC box girders of length 17.14m. Plan of Yoshida Bridge is shown in Fig.1.

2. Methodology

Microtremor measurements were carried out at different major stages of bridge construction. Following were the major stages at which microtremor measurement were conducted.

1. Individual girder at factory.
2. After placement of girders at site.
3. After the transverse prestressing of girders.
4. After the grouting of duct provided for prestressing.
5. Before concreting of curve portion of bridge.
6. After concreting of curve portion of bridge.

During the microtremor measurement of individual PC girder at factory, sensors were placed at each quarter span of girder. Sensors were able to measure three dimensional microtremor and X was always oriented along longitudinal direction of girder.

During measurement at site, sensors were placed at mid span of each girder named with G1,G2é .G13,G14 and one sensor was placed at abutment of the bridge. The configuration of sensor is shown schematically in fig.2. Measurement was taken by giving impact on girder by hammer. In this study impact is considered as a source of excitation of bridge structure at micro amplitude. The duration of measurement was 3minute with sampling frequency of 200Hz. Velocity time histories were drawn for each girder. The velocity time histories were then transformed to frequency domain using Fast Fourier Transform. The maximum number of points used to calculate the transform was 4096 points. Finally predominant frequency and damping ratio were calculated from extracted data.

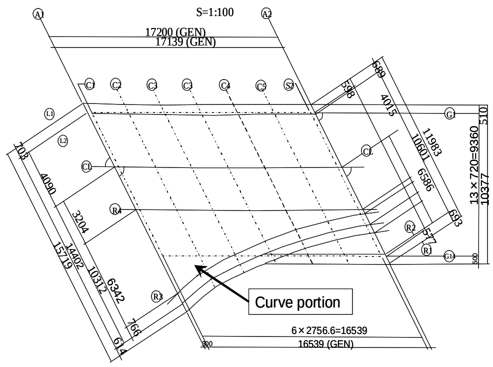

Fig.1 Plan view of Yoshida Bridge

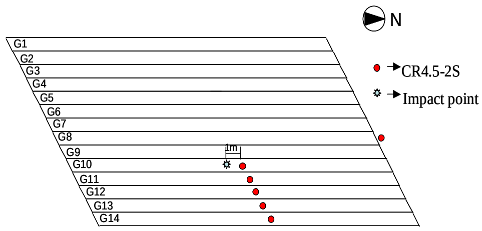

Fig.2 Configuration of sensors

3. Results and discussions

The results obtained at each stage of microtremor observation were described in following sub heading.

3.1 Individual PC girder at factory

At PC girders manufacturing factory, microtremor measurement of two girders named G9 and G11 of Yoshida Bridge were taken. The predominant frequency of G9 girder was 6.34Hz and that of G11 girder was 5.85Hz. Fourier spectrum is shown in fig.3. All the conditions during the measurement were identical expect the wooden support for G9 girder and steel roller support for G11 girder. From this observation, it can be concluded that the supporting material (boundary condition) has a significant influence on the predominant frequency of PC girders.

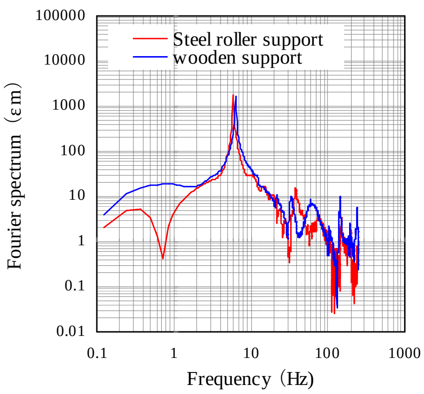

Fig.3 Fourier spectrum of G9 and G11

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3.2 After placement of girders at site

Sample of velocity time histories are shown in fig.4 and fig.5. The Fourier spectra at different phases of bridge construction are shown in fig.6. The summaries of predominant frequencies at different phases of bridge construction are shown in fig.7. After installation of girders at site, the average predominant frequency and damping ratio were observed as 6.09Hz and 0.02 respectively.

3.3 After transverse prestressing

Immediately after the transverse prestressing of girders, the average predominant frequency was 6.64Hz. There was an increment of 0.55Hz after prestressing. By taking the ratio of above two frequencies before and after prestressing, it can be concluded that about 18% stiffness was increased by prestressing. Therefore, flexural rigidity of girders has increased after prestressing. However, damping ratio was found to be decreased. The average damping ratio was 0.015.

3.4 After grouting of duct

Microtremor measurement was taken immediately after completion of grouting of duct. The average predominant frequency was 6.64Hz and average damping ratio was 0.017. With reference to these data, it can be concluded that grouting has no significant effect on predominant frequency.

3.5 Before and after concreting of curve portion

Average predominant frequency and damping ratio before concreting of curve portion of Yoshida Bridge were 6.68Hz and 0.18 respectively. The average predominant frequency of girder was 7.08Hz after casting of curve portion and average damping ratio was 0.015. Therefore it can be concluded that additional RC curve portion has contributed for the greater flexural rigidity of the integrity of bridge.

4. Conclusions

1. The supporting material (boundary condition) has significant influence on the predominant frequencies of PC girders.
2. The predominant frequencies of PC girders have increased significantly after transverse prestressing. Transverse prestressing has a vital role in rigid connection of PC girders. Therefore, prestressing has contributed to greater flexural rigidity and enlarged the elastic range of bridge structure.
3. Additional RC member to PC girder has also increased the flexural rigidity of integrity of bridge structure.

5. Acknowledgements

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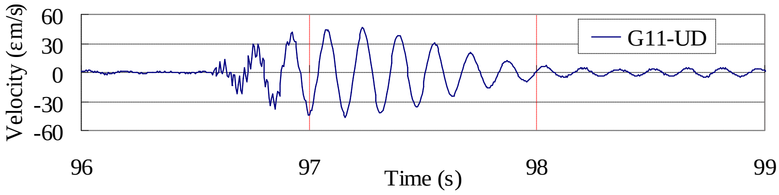

Fig.4 Velocity time history of G11 after placement girders at site.

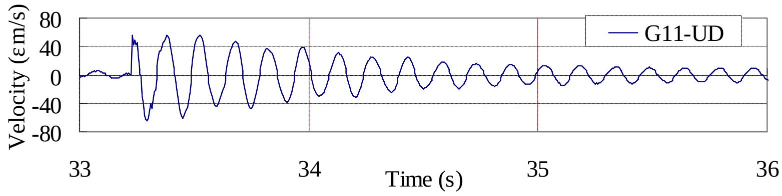

Fig.5 Velocity time history of G11 after transverse prestressing.

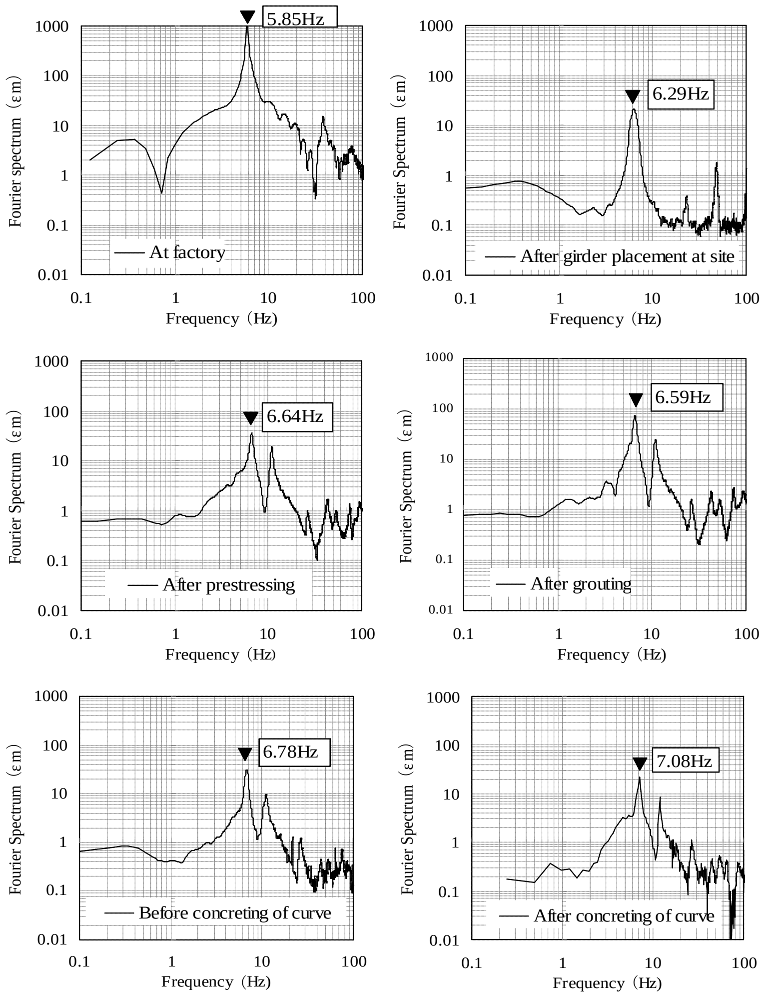

Fig.6 Fourier spectrum of PC girder G11 at different stages.

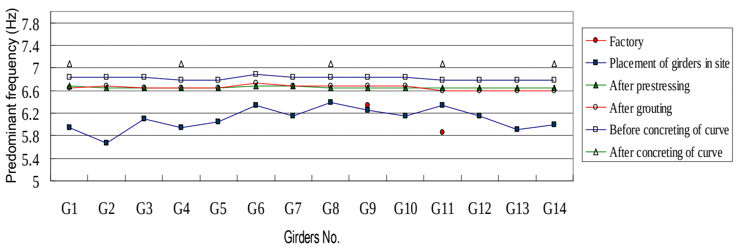

Fig.7 Predominant frequency of PC girders.